Birat Journal Of Health Sciences
ISSN (Online): 2542-2804 • Quarterly • Vol. 12, No. 4 (2026)

# METHIONINE-CAPPED HYDROXYAPATITE NANOPARTICLES MITIGATE SALINITY-INDUCED STRESS AND IMPROVE GROWTH AND PHYSIOLOGICAL PERFORMANCE IN BRASSICA NAPUS L.

**[1]Dr. Faysal Rana, [2]Dr. Atiqur Rahman**
[1]Sir Salimullah Medical College (Dhaka). faysal@ssmc.edu.bn
[2]Chattogram Medical College (Chattogram). atiqurrehman.md@yahoo.com

**ARTICLE HISTORY**

| RECEIVED | REVISED | ACCEPTED | PUBLISHED ONLINE |
|---|---|---|---|
| *[25 Sept 2026]* | *[18 Oct 2026]* | *[02 Nov 2026]* | *[1 2Nov, 2026]* |

## Abstract

*Salinity is an important abiotic constraint to crop establishment and productivity. This study evaluated the response of canola (Brassica napus L. cv. NST-20) to induced NaCl stress and methionine-capped hydroxyapatite nanoparticles (HANPs). Seeds obtained from the National Agricultural Research Centre, Islamabad, were exposed to nanoparticle solutions before sowing, and plants were assessed under six treatment conditions involving a control, 50 and 100 mM salt stress, and nanoparticle-associated treatments. Growth traits included total plant, leaf, stem and root length and fresh weight; biochemical measurements included soluble sugars, protein, proline, chlorophyll a, chlorophyll b, total chlorophyll and carotenoids. The research reports that salt stress generally reduced growth and pigment-related traits, with stronger reductions commonly observed at 100 mM NaCl. HANP-associated treatments were reported to improve several growth and biochemical parameters relative to salt-stressed treatments. The largest reported increases included carotenoids (2.89-fold), chlorophyll a (2.84-fold), total chlorophyll (2.30-fold), protein (1.97-fold) and proline (1.73-fold) in the control plus HANPs treatment. These findings suggest a potential ameliorative effect of methionine-capped HANPs in canola exposed to salinity. However, complete numerical datasets, replication details and a fully specified statistical procedure were not available in the research text; these details must be verified before journal submission.*

**COPYRIGHT & LICENSE**

**Copyright © 2026 The Author(s).** All rights reserved by the author(s), who retain copyright ownership of their original work. The author(s) grant the **Birat Journal of Health Sciences (BJHS)** a non-exclusive right of first publication.

**Open Access License:** This article is published under the [Creative Commons Attribution 4.0 International (CC BY 4.0) License](https://creativecommons.org/licenses/by/4.0/), permitting unrestricted use, distribution, reproduction, and adaptation in any medium, including commercial use, provided that appropriate credit is given to the original author(s), the source and the license, and any modifications are clearly indicated.

## Introduction

Soil salinity restricts plant growth by lowering soil water potential and disturbing ionic balance. The initial osmotic component of salt stress can reduce water uptake and cell expansion, while prolonged exposure may cause excessive accumulation of Na+ and Cl−, nutrient imbalance, membrane injury and oxidative stress. These effects can impair photosynresearch, reduce pigment content and ultimately limit plant biomass and yield (Munns and Tester, 2008; Van Zelm et al., 2020).

Canola (Brassica napus L.) is an economically important oilseed crop cultivated for edible oil and protein-rich seed meal. Its productivity can be affected by salinity, particularly during germination and early vegetative growth. Identifying practical approaches to mitigate salt-induced injury is therefore relevant to crop production in salt-affected environments.

Hydroxyapatite [Ca10(PO4)6(OH)2] is a calcium-phosphate material that has been investigated as a phosphorus-containing nanomaterial. Its agricultural effects may depend on particle properties, dose, plant species and exposure conditions. Recent work has reported beneficial growth responses to hydroxyapatite nanoparticles in some Brassica plants, while other studies indicate that nanoparticle effects can be concentration- and species-dependent (Elsayed et al., 2023; Ochoa et al., 2021). Surface modification with methionine may alter particle–plant interactions, but its influence under salinity requires further evaluation.

The present study, as documented in the source research, examined growth and selected biochemical traits of B. napus cv. NST-20 under 50 and 100 mM salt stress in association with methionine-capped HANPs. The objective was to assess whether HANP treatments were associated with improved growth and physiological status under induced salinity.

## 2. Materials and Methods

### 2.1. Experimental site and plant material

The experiment was conducted in the Botany laboratory area of Government Degree College Lahor, Swabi, Khyber Pakhtunkhwa, Pakistan. Seeds of B. napus cv. NST-20 were obtained from the National Agricultural Research Centre (NARC), Islamabad. The research reports that seeds were primed for 24 h in nanoparticle solutions and subsequently sown in pots.

### 2.2. Nanoparticle material

Methionine-capped hydroxyapatite nanoparticles were obtained from the Department of Botany, University of Peshawar. The research describes the particles as methionine-modified hydroxyapatite, with a reported size range of approximately 10–50 nm and a hexagonal crystalline structure. The stated chemical composition was Ca10(PO4)6(OH)2 with methionine (C5H11NO2S) as the capping molecule. The research attributes synresearch to a wet-chemical precipitation procedure; detailed synresearch and physicochemical characterization data were not provided in the experimental methods.

### 2.3. Seed priming and treatment design

A total of 180 seeds was reported. Seeds were primed for 24 h in nanoparticle suspensions at 100 or 500 ppm before sowing. Six treatment groups were described (Table 1). The source research does not provide a complete allocation of the 180 seeds among all six groups, the number of pots per treatment, or the number of biological replicates.

| Treatment | Description |
|---|---|
| T1 | Control |
| T2 | 50 mM salt stress |
| T3 | 100 mM salt stress |
| T4 | Control + 500 ppm HANPs |
| T5 | 50 mM salt stress + 100 ppm HANPs |
| T6 | 100 mM salt stress + 500 ppm HANPs |

The research states that 0.5 g of nanoparticles was dissolved in 1,000 mL distilled water, which corresponds to 500 ppm (0.5 g L−1). The preparation procedure for the 100 ppm suspension and the exact timing and method of NaCl application were not fully specified in the research.

### 2.4. Measurement of growth traits

The reported growth variables were total plant length, leaf length, stem length, root length, total plant weight, leaf weight, stem weight and root weight. The research presents treatment comparisons graphically and reports selected fold changes relative to the control or other stated comparison groups. Raw replicate-level measurements and complete mean ± variation values were not available in the supplied research text.

### 2.5. Biochemical analyses

Chlorophyll and carotenoids were extracted from 0.1 g fresh leaf tissue using 80% acetone. The extract was centrifuged at 1,000 rpm for 5 min, the supernatant volume was adjusted to 7 mL,

and absorbance was recorded at 480, 645, 663 and 510 nm. The research cites Arnon (1949) for pigment analysis.

Soluble sugars were determined using the phenol–sulfuric acid procedure attributed to Dubois et al. (1956), with absorbance recorded at 485 nm. Proline was extracted from 0.1 g fresh leaf tissue in 3% sulfosalicylic acid; the extract was reacted with ninhydrin and glacial acetic acid, heated in a water bath, and absorbance was measured at 520 nm. Protein was estimated using the Lowry procedure (Lowry et al., 1951), with absorbance recorded at 650 nm.

### 2.6. Statistical analysis

The research states that data were analysed using SPSS and analysis of variance (ANOVA), and graphs were prepared using GraphPad Prism. However, the specific ANOVA model, replicate number, post-hoc test, exact p-values and definition of error bars are not reported consistently. Statistical significance is therefore described here only as reported in the research and requires confirmation from the original statistical output.

## 3. Results

### 3.1. Growth responses

The research reports that salt stress reduced total plant length to 0.88- and 0.80-fold at 50 and 100 mM NaCl, respectively. HANP-associated treatments were reported to increase plant length, with 1.39-fold in T4 and 0.93-fold in T6. Leaf length was reported as 0.95- and 0.88-fold under T2 and T3, while T4, T5 and T6 were reported as 1.34-, 0.86- and 0.93-fold, respectively.

Stem length was reported to decline under salt stress and to increase in the HANP-associated groups, with a maximum reported fold value of 1.53 in T4. Root length declined to 0.81- and 0.70-fold under T2 and T3; the research reports 1.47-fold in T4, 0.74-fold in T5 and 0.84-fold in T6. Overall plant weight was reported as 0.84- and 0.76-fold under T2 and T3, compared with 1.25-, 1.01- and 0.86-fold in T4–T6.

Leaf, stem and root weights showed broadly similar patterns in the research narrative: salt stress was associated with lower values, while HANP treatments were associated with increases. Some reported fold values are internally inconsistent or contain apparent transcription errors (notably the T6 leaf-weight value); these values have not been reproduced as quantitative findings in this article pending verification against the original data.

### 3.2. Biochemical responses

Soluble sugar content was reported to be lower under salt stress (0.96-fold in T2 and 0.63-fold in T3) and higher in HANP-associated groups (1.40-, 1.12- and 1.30-fold in T4–T6). Protein content was reported as 0.81- and 0.73-fold under T2 and T3, compared with 1.97-, 1.31- and 1.69-fold in T4–T6.

Proline content was reported as 0.71-, 0.46- and 0.40-fold in T1–T3 and 1.73-, 1.18- and 1.32-fold in T4–T6. Chlorophyll a was reported to decline under salt stress (0.57- and 0.52-fold in T2 and T3), while the largest reported increase was 2.84-fold in T4. Chlorophyll b was reported as 0.80- and 0.64-fold in T2 and T3, with a maximum of 1.87-fold in T4. Total chlorophyll was reported to increase by 2.30-, 1.29- and 2.09-fold in T4–T6. Carotenoids declined to 0.43- and 0.37-fold under T2 and T3 and were reported as 2.89-, 1.84- and 2.04-fold in T4–T6.

| Parameter | Salt-stress response reported | HANP-associated response reported |
|---|---|---|
| Total plant length | T2: 0.88; T3: 0.80 | T4: 1.39; T6: 0.93 |
| Leaf length | T2: 0.95; T3: 0.88 | T4: 1.34; T5: 0.86; T6: 0.93 |
| Stem length | Reduced under T2/T3 | Maximum: T4, 1.53 |
| Root length | T2: 0.81; T3: 0.70 | T4: 1.47; T5: 0.74; T6: 0.84 |
| Total plant weight | T2: 0.84; T3: 0.76 | T4: 1.25; T5: 1.01; T6: 0.86 |
| Soluble sugars | T2: 0.96; T3: 0.63 | T4: 1.40; T5: 1.12; T6: 1.30 |
| Protein | T2: 0.81; T3: 0.73 | T4: 1.97; T5: 1.31; T6: 1.69 |

| | | |
|---|---|---|
| Proline | T2: 0.46; T3: 0.40 | T4: 1.73; T5: 1.18; T6: 1.32 |
| Chlorophyll a | T2: 0.57; T3: 0.52 | T4 maximum: 2.84 |
| Chlorophyll b | T2: 0.80; T3: 0.64 | T4 maximum: 1.87 |
| Total chlorophyll | Lower in T2/T3 | T4: 2.30; T5: 1.29; T6: 2.09 |
| Carotenoids | T2: 0.43; T3: 0.37 | T4: 2.89; T5: 1.84; T6: 2.04 |

Note: Fold values are transcribed from the research narrative and are not raw means. The research does not consistently define the denominator/reference group for every fold value; values should be checked against the original datasets before publication.

## 4. Discussion

The overall pattern described in the research is consistent with the well-established negative effects of salinity on plant growth and photosynthetic traits. Osmotic stress can restrict water uptake and cell expansion, while ionic imbalance and oxidative stress can disrupt membranes and photosynthetic machinery (Munns and Tester, 2008; Van Zelm et al., 2020). The reported decreases in plant length, biomass, chlorophyll and carotenoid contents under 50 and 100 mM salt stress are broadly consistent with these mechanisms.

HANP-associated treatments were reported to improve several morphological and biochemical traits compared with salt-stressed groups. Hydroxyapatite nanoparticles have been investigated as a potential phosphorus source for plants, and a recent study reported positive growth responses in Brassica species at selected application rates (Elsayed et al., 2023). Nevertheless, nanoparticle responses are dose- and species-dependent, and the current research does not include a conventional phosphorus-fertilizer comparator or detailed nanoparticle characterization data that would allow the mechanism to be established.

The reported increases in chlorophyll and carotenoids may indicate better preservation of photosynthetic pigments in HANP-treated plants. Higher soluble sugar and protein levels may reflect altered carbon and nitrogen metabolism, while proline accumulation can contribute to osmotic adjustment and stress protection. However, the source research reports lower proline under salt stress and higher values in HANP groups; without raw values, sampling details and assay calibration data, these trends should be interpreted cautiously.

Several design and reporting limitations constrain the strength of the conclusions. The treatment table does not clearly distinguish seed priming from foliar application, although the abstract and conclusion refer to foliar application while the methods describe seed priming. The nanoparticle preparation information does not explain how the 100 ppm treatment was prepared. Replicate numbers, pot allocation, growth conditions, duration of salt exposure, exact NaCl application schedule and full statistical outputs are missing. In addition, some fold-change values and significance statements are inconsistent. These issues should be resolved before the results are treated as definitive evidence of efficacy.

## 5. Conclusion

Within the limits of the information reported in the source research, salt stress was associated with reduced growth and photosynthetic pigment levels in B. napus cv. NST-20, whereas methionine-capped HANP-associated treatments were reported to improve several growth and biochemical parameters. The results indicate that methionine-capped hydroxyapatite nanoparticles warrant further investigation as a possible approach to support canola under salinity. A definitive conclusion about treatment efficacy, optimal concentration or field applicability requires verification of the original data, clarification of the application route and a fully documented replicated experiment

## References

Arnon, D.I. (1949). Copper enzymes in isolated chloroplasts. Polyphenoloxidase in Beta vulgaris. Plant Physiology, 24, 1–15.

Dubois, M., Gilles, K.A., Hamilton, J.K., Rebers, P.A. and Smith, F. (1956). Colorimetric method for determination of sugars and related substances. Analytical Chemistry, 28, 350–356.

Elsayed, R.S.A., El-Ziat, R., Taha, Z., Farag, H. and AbouAitah, K. (2023). Hydroxyapatite nanoparticles as effective phosphorus nano-fertilizer on Brassica plants. DOI: 10.21608/SJAS.2023.185609.1278.

Lowry, O.H., Rosebrough, N.J., Farr, A.L. and Randall, R.J. (1951). Protein measurement with the Folin phenol reagent. Journal of Biological Chemistry, 193, 265–275.

Munns, R. and Tester, M. (2008). Mechanisms of salinity tolerance. Annual Review of Plant Biology, 59, 651–681.

Ochoa, S.L., Ortega-Lara, W. and Guerrero-Beltrán, C.E. (2021). Hydroxyapatite nanoparticles in drug delivery: Physicochemistry and applications. Pharmaceutics, 13(10), 1642.

Van Zelm, E., Zhang, Y. and Testerink, C. (2020). Salt tolerance mechanisms of plants. Annual Review of Plant Biology, 71, 403–433.